NEW WELL OF LARGE CAPACITY AT THE UNIVERSITY OF ILLINOIS[1]

By M. L. Enger

The water supply of the University of Illinois is obtained from six wells in the glacial drift. The following table concerning the first five wells put in is taken from a paper presented at a previous meeting of this Section.[2]

	WELL NUMBER				
	1	2	3	4	5
Depth, feet	138	140	142	140	140
Diameter, inches	8	8	8	12	12
Cost of motor pump and well	$934	$1359	$1487	$2106	$1701
Capacity, gallons per minute	60	69	81	71	75

Owing to the increased demand for water and because of trouble with the well pumps, the above equipment became inadequate. Accordingly, in October, 1915, the University entered into a contract with the Layne & Bowler Company, of Memphis, Tenn., for a well and motor-driven pump. The payment agreed upon was $19 per gallon per minute after one year's operation. It was stipulated that the minimum over-all efficiency of the motor and pump was to be 55 per cent.

The well was drilled by the rotary process, beginning January 17, and finishing May 5, 1916. The well is 36 inches in diameter to a depth of 160 feet and 30 inches in diameter for the next 9 feet. The driller furnished the following log:

	feet
50 feet of clay and gravel mixed	50
15 feet of clay and rock	65
30 feet of hard clay and sand mixed	95
47 feet of hard sand and gravel	142
26 feet of very hard and fine sand	168
5 feet of hard sand and a little clay	173

[1] Read before the Illinois Section, March 25, 1919.

[2] Some Costs of Maintenance of Motor Driven Well Pumps, Journal, June, 1917, p. 190.

The well was completed by putting in 98 feet of 24-inch, No. 8 gauge casing; 70 feet of 24-inch, No. 6 Layne patent shutter screen, No. 8 gauge; and 4 feet of shutter seal, 16 inches by 22 inches with a 6-inch cypress bottom. The space between the screen and casing and the wall of the well was filled with 1-inch gravel.

A turbine pump was placed in the well, and was started and stopped frequently in order to break down and wash away the mud wall which had been left by the drilling process, and also to carry away the finer particles of sand in the water-bearing stratum near the well. It was hoped in this way to form a cavity under the heavy clay roof, indicated in the above log, into which the gravel would flow and thus increase the capacity of the well. The driller states that about 30 cubic yards of gravel were fed in at the top.

A preliminary test showed a yield of more than 1000 gallons per minute with a draw-down of 53 feet, or a specific capacity of more than 19 gallons per minute per foot of draw-down. The well now has a specific capacity of 21.5 gallons per minute. Data concerning well 4 will be of interest in making comparisons. The well was tested immediately after its construction in 1906 and showed a yield of 108 gallons per minute with a draw-down of 15 feet, or a specific capacity of 7.2 gallons per minute. In 1916 the yield of this well was 71 gallons per minute with a draw-down of 14.6 feet, or a specific capacity of 4.9 gallons per minute. That is to say, well 4 in ten years of operation has had its specific capacity reduced more than 30 per cent, while the new well in about two years of normal use has had its specific capacity increased by about 10 per cent.

It was soon found that a yield of 1000 gallons per minute could not be maintained for any length of time without having the water level in the well and in the older wells gradually fall. A test was begun April 11, 1917, in which it was intended to run the pump continuously until the water level in the well should become constant. The water level went down quite rapidly during the first two days of the test and it continued to go down slowly until the morning of April 25, when some trouble at the switchboard caused the circuit breaker to blow out, stopping the pump. It was started again about twenty minutes later, but during the interval the hydraulic constants of the well had been changed greatly. Before the pump was stopped the discharge had been about 670 gallons per minute for several days. When the pump was started again the discharge was about 790 gallons per minute and twenty-four hours later it was about 710 gallons

per minute. The curves in figure 1 show the water level in the well and the discharge during the test. The change in the hydraulic constants was probably due to the fine sand drifting toward the well becoming entangled, gradually choking up the water-bearing stratum

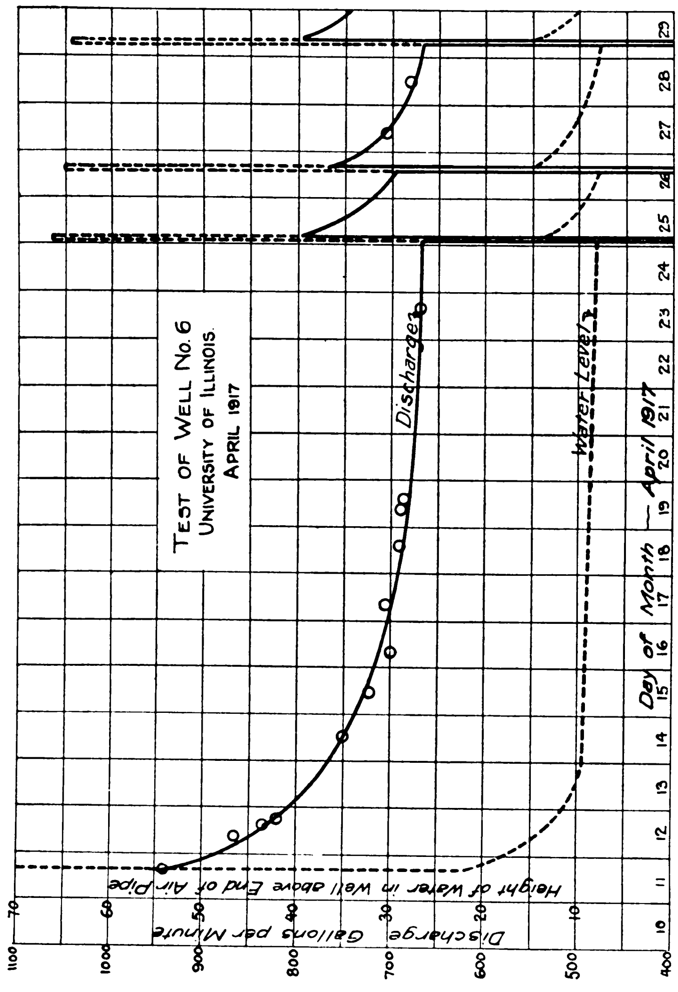

FIG. 1. DISCHARGE AND WATER LEVEL IN 24-INCH WELL DURING TEST

near the well. When the pump was stopped, the flow toward the well ceased, allowing some readjustment in the positions of the sand grains. When the pump was again put into operation some of the sand was washed into the well, leaving the water passages near the well less restricted.

The temporary installation was replaced by a six-stage, No. 4, 15-inch type CLC Layne pump driven by a 50-horse-power Westinghouse 2-phase induction motor through a flexible coupling.

The pump is located in a pit 12 by 12 feet, 11 feet deep, with concrete bottom, sides and roof. The pit is drained into a tunnel which carries the steam heating pipes into an adjacent building. Before the concrete floor was put in, the gravel between the casing and the wall of the well was replaced with clay to a depth of 6 feet below the floor of the pit. There seems to be no chance for contamination to

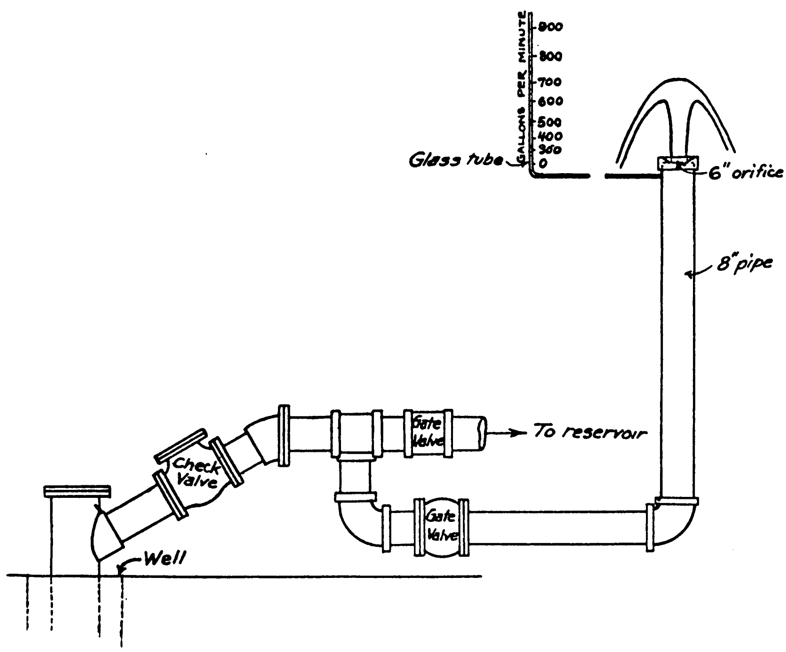

FIG. 2. APPARATUS FOR MEASURING DISCHARGE FROM WELL

get into the well. Frequent tests of the water have shown it to be of excellent sanitary quality.

In order to obtain continuous records of the water level in the well, a recording guage is used to record the pressure required to keep a small quantity of air bubbling from the end of a $1\frac{1}{2}$-inch pipe which hangs in the well and extends below water level at all times. The pressure in the air pipe is equal to the head of water above the bend of the pipe, hence the guage shows the submiergence of the end of the air pipe at all times. The records show when the pump is started

and stopped and are found very useful in the preparation of operation statistics.

In order that the discharge may be measured at any time, a vertical jet apparatus has been installed in a manhole just outside of the concrete pit. The manhole is drained by a 12-inch vitrified pipe discharging into a storm sewer. The vertical jet apparatus was calibrated in the Hydraulics Laboratory by setting up the entire pipe line from the valve to the orifice. The equation of the orifice was found to be $Q = 530\sqrt{h}$ gallons per minute, h being the head in feet measured by a piezometer connected to the pipe 3 inches below the orifice. The pipe is 8 inches and the orifice is a 6-inch circular hole drilled in an 8-inch cap screwed to the end of the pipe. The general arrangement is shown in figure 2.

An acceptance test was made December 28, 1918, showing an average over-all efficiency of 55.6 per cent when delivering 587 gallons per minute against a head of 136.9 feet, and an efficiency of 59.3 per cent when delivering 536 gallons per minute against a head of 156.4 feet.

Compared with the University's other well equipment the new one has the disadvantage of a 15-foot greater draw-down. But since it has never been possible to maintain the average efficiency of the reciprocating well pumps as high as 50 per cent, the turbine pump will get the water out of the ground with a smaller power consumption than the reciprocating pumps. In the cost of maintenance the new unit seems to have a considerable advantage over the older ones. With the older equipment the cost of maintenance has amounted to about 0.8 cent per 1000 gallons. The new equipment has not been in use long enough to draw definite conclusions, but the indications are that the maintenance cost will be comparatively small.

DISCUSSION

C. B. Burdick: There is no doubt of the practicability to increase greatly the yield per well in fine materials by the construction of a packed gravel well, such as has been described in the paper. Whether it is wise to construct such a well will always depend upon the cost and capacity of the well as compared with wells of small diameter and a lower cost in connection with the yield that is practicable to secure from them. Consideration should also be given to the cost

of pumping, considering the differences, if any, in the pumping machinery applicable to the wells of various diameters.

It is stated that the large well described in the paper cost about $10,000, and that its yield when first drilled was about 20 gallons per minute per foot of draw-down. It is further stated that the small tubular wells previously used at the University cost from $900 to $1500 per well and delivered, when pumped singly, about 7 gallons per minute per foot of draw-down.

Although the well described produced a large flow as compared to the wells previously used, its specific capacity is not great even as compared with tubular wells in the coarser underground strata. The wells supplying Camp Grant, constructed in 1917, were 10 inches in diameter, with the strainer from 10 to 20 feet in length, in sand averaging about 0.35 mm. in effective size. The specific capacities of these wells, pumped individually, ranged from 18 to 44.5 gallons per minute per foot of draw-down. The average delivery of five wells in a row 300 feet on centers, was 77 per cent of the sum of the specific capacities of the individual wells. The water-bearing stratum was not less than 30 to 50 feet in thickness. At Des Moines a 6-inch well in a 20-foot water-bearing stratum with sand 0.42 mm. in effective size, showed a specific capacity of 37. At South Bend, 6-inch wells in a 50-foot water-bearing sand stratum, in effective size ranging from 0.3 to 0.5 mm., showed capacities ranging from 31 to 38. At La Crosse, Wis., a 6-inch well in a 140-foot sand stratum, having a size of about 0.5 mm. near the strainer, showed a capacity of 23; a 10-inch well in similar materials a capacity of 37. At Benton Harbor, Mich., 6-inch wells in sand stratums from 20 to 60 feet thick, with sand sizes varying from 0.33 to 0.47 mm. in effective size, gave specific capacities from 22 to 44.

The coarser the water-bearing material the smaller is the gain by the construction of a so-called packed gravel well, and before constructing such wells it is proper to consider what can be done with wells more cheaply constructed, for the best well is the one that produces the desired quantity of water at the least cost per gallon, taking into consideration the initial expenditure and the cost of operation.

A. N. TALBOT: The other wells of the University have a yield of 75 to 100 gallons per minute and it was thought that so high a yield as 500 gallons per minute could not be expected. The water-bearing sand is very fine, and it has given trouble in other wells.

P. E. Green: In the case of a deep well, in which the drop pipe is only slightly smaller than the outside casing, what is the best way to measure the draw-down? Suppose the space between the drop pipe and the casing is not large enough to put even a line pipe between them. One might get an insulated wire down, but the space is not large enough to get any pressure contact device down. The speaker thought that if he could drop a wire forming part of a bell and dry-circuit, the water would make a connection, but this did not work.

A.V. Beauchemin: A way to find the level of the water in the well is to take a small rubber tube and simply put the tube in the well between the casing and the discharge pipe. On the other end of the tube put a bit of glass U tube with water in it. When the rubber tube reaches the water in the well, air pressure will push water in the glass tube up. This is often better than electrical measurement. Sometimes a brass tube is placed at the end of the rubber tube to give weight to carry it down.

M. L. Enger: On one of the University wells the space between the drop pipe and the casing is so small nothing can be put between them. After pumping, it is customary to wait until there is time for a sufficient leakage through the pump to bring the water level in the drop pipe or discharge pipe to the level of the water in the well, and then pump until water appears at the surface. If the slip of the pump and the capacity of the drop pipe are known and the number of strokes of the pump necessary to fill the drop pipe is determined, the depth of the water in the well may be computed.

C. B. Burdick: Pumps in tubular wells should always be equipped with a water-level measuring device when installed, of which probably the best is a small pipe attached to the outside of the pump discharge pipe, from which the water level can be measured by means of compressed air and an ordinary pressure gauge, knowing the elevation of the lower end of the air pipe. Brass tubing $\frac{1}{8}$ inch in diameter, such as is used in gasoline lighting systems will answer this purpose. Where the well has not been so equipped the speaker has frequently used a telephone magneto and a weighted wire dropped into the space between the casings. The magneto is grounded on the pump casing, and will produce a ring where the water touches the water. It is necessary to protect the tip of the wire by placing it

inside a small piece of wall conduit. It can be held in place with paraffin and the tubing weighted with small shot so as to straighten out the wire. It is necessary, of course, to use weather-proof wire.

If the space between the casings is too small to admit the wire, it is practicable to use the annular space between the casings as an air pipe by closing the top of it and subjecting it to air pressure, then the location of the water level between the casings will be evidenced by the maximum pressure required to depress the water to the bottom of the pump. This reduced to feet of water and measured upward from the bottom of the pump will give the height to which the water stands outside the pump casing.